THE NATIONAL SOIL DYNAMICS LABORATORY
United States Department of Agriculture
Agricultural Research Service

International Historic Mechanical Engineering Landmark
and
Historic Landmark of Agricultural Engineering

October 19, 1990
Auburn, Alabama

The American Society of Mechanical Engineers

American Society of Agricultural Engineers

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United States Department of Agriculture
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International Historic
Mechanical Engineering Landmark

National Soil Dynamics Laboratory
Auburn, Alabama
1935

The National Soil Dynamics Laboratory was the world's first full-size laboratory for controlled studies of the relationships between tillage tools and traction equipment, and various types of soils. Conceived by Mark L. Nichols and John W. Randolph, the facility incorporates rail-mounted cars to isolate the equipment under test from external influences. Research performed here has influenced the design of almost all modern agricultural equipment. Although it has inspired the design of over a dozen other facilities this remains the largest and most complete laboratory of its kind in the world.

The American Society of Mechanical Engineers -1990

A Historic Landmark
of
Agricultural Engineering

Tillage and Traction Equipment Design Criteria

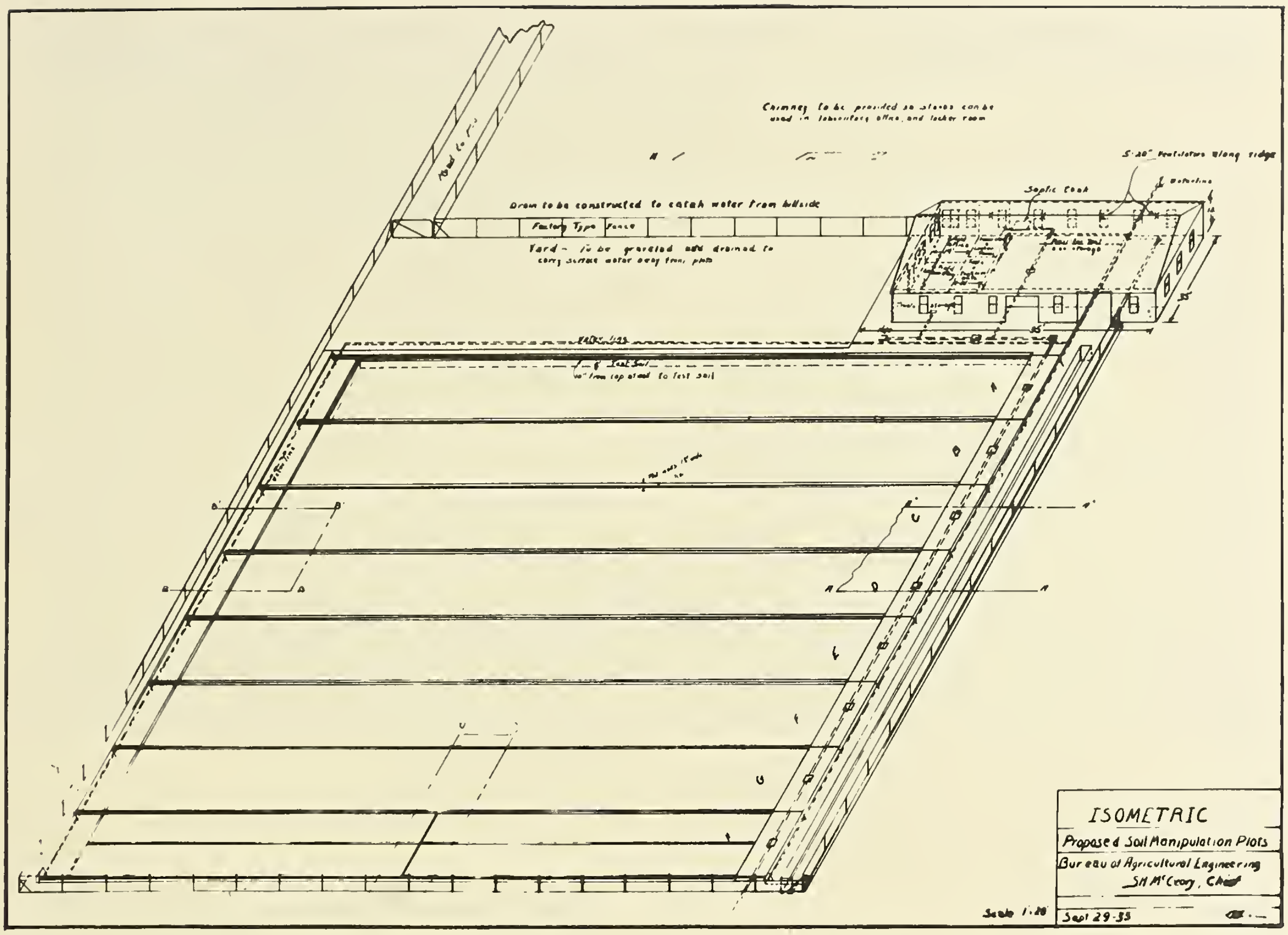
Historically, farm tillage tools were designed without scientific knowledge of how tools work the soil. Thus, a tool designed to operate in one soil pulled by a mule might not operate satisfactorily in another soil or when pulled by a tractor at higher speeds. Traction and flotation problems appeared with the introduction of tractors. The importance of developing a scientific approach to the study of tillage and traction became apparent during the transition from animal to mechanical power.

Because of the pioneering work in soil dynamics initiated in 1922 by Dr. Mark L. Nichols, Professor of Agricultural Engineering at Auburn University, the Farm Tillage Machinery Laboratory, now the National Soil Dynamics Laboratory, was established at this location in 1933.

The study of soil dynamics has defined how traction devices and tillage tools operate on different soils and soil conditions. It has also provided design criteria which manufacturers have used to improve the efficiency of tillage implements, such as plows, harrows, planters and cultivators, and traction and transport machines, such as tractors, combines, and trailers.

The discipline of soil dynamics; pioneered, defined and developed at this location; has allowed manufacturers to provide farmers around the world with machinery that produces more effective tillage and traction while minimizing soil compaction and conserving soil, water, and energy.

Dedicated
by the
American Society of Agricultural Engineers
(1990)



A USDA, Bureau of Agricultural Engineering sketch dated September 29, 1933 illustrating the proposed soil manipulation plots.

A Historical Perspective

The National Soil Dynamics Laboratory (NSDL) was established as the Farm Tillage Machinery Laboratory in 1933. Research conducted by Dr. Mark L. Nichols and Mr. John W. Randolph in the Agricultural Engineering Department of the Alabama Polytechnic Institute, now Auburn University, strongly influenced the site of the Laboratory.

In 1922 the Gulf Coast Horticultural Society asked the Alabama Agricultural Experiment Station for help in improving the traction of agricultural tractors on the sandy soils of South Alabama. The complaint, as stated by Nichols, was that the tractors "could not pull the hat off your head." That single request started a series of events that, through research on the interaction between machines and soils, ultimately resulted in construction of the Farm Tillage Machinery Laboratory by the Bureau of Agricultural Engineering, United States Department of Agriculture (USDA).

The large scale introduction of tractors into agriculture as a means of increasing production was the start of the complete mechanization of agriculture. Engineers generally became engrossed in the redesign and strengthening of animal-drawn machines for use with tractors. Nichols saw the relation of the machine with the soil as a fundamental aspect of agricultural machine design that would improve the quality of machine performance. The Nichols-Randolph research developed the basic principles of soil dynamics in order to relate the dynamic reaction of soil to the application of mechanical forces by machines.

The importance of soil dynamics to the country and the esteem with which it was held in the engineering community was reflected in the following statement that appeared on the cover of AGRICULTURAL ENGINEERING, The Journal of the American Society of Agricultural Engineers, January, 1927 under the title

Mark L. Nichols (1888 - 1971)

"Agricultural Engineering Exemplified": *"Within our own profession we know what agricultural engineering is and does, but there may be occasions for the setting up of a specific example which shall be vivid, typical, symbolic. Such we have in the researches into soil dynamics being conducted at several of the land grant colleges and experiment stations, notably at Alabama. The subject matter distinguishes it sharply from any other branch of engineering, and the manner and purpose of study set it apart from any other aspect of agriculture. As research it meets the most exacting definition; at the same time its practical value is apparent even to the layman. Though this work were suspended today and all other achievement of the profession swept away, soil dynamics would remain an indisputable monument to agricultural engineering."*

In 1927 a USDA agricultural engineering advisory committee was established to determine the nature and direction for increased research in mechanical farm equipment. Nichols, was a key member of the committee which formulated recommendations that resulted in the establishment of the USDA Cotton Production Machinery Project (CPMP) in Auburn, Alabama in 1930. The project was located in Auburn to build on the soil dynamics research program developed by Nichols and Randolph. Randolph was employed by the USDA and placed in charge of the new USDA project.

As the soil dynamics research program developed at the Alabama Polytechnic Institute and the field work of the CPMP progressed, it became evident by the early 1930's that it was not possible to determine the affect of isolated machine components and parameters on the forces and soil reactions in field conditions. Because that was the data designers needed, a laboratory with large soil bins and special measuring equipment was needed to continue the research on full-scale machines.

Nichols petitioned the Alabama Legislature to establish a "soil manipulation area" for the research. Due to the Depression, the governor of Alabama could not support the construction of such a facility. Subsequently on August 3, 1933, when the Public Works Administration (PWA) was established and federal funds became available, Randolph inquired of USDA whether PWA funds could be secured to build the facility. Upon receiving strong support from southern universities, congressmen and the American Farm Bureau Federation, on October 10, 1933, President Franklin D. Roosevelt authorized a $110,975 allotment of PWA funds for the construction of the Farm Tillage Machinery Laboratory in Auburn, Alabama, as the world's first full-scale soil bin facility.

Following approval, Randolph initiated detailed planning by visiting Langley Field and the Navy Department in Washington to study the design of their high speed traction cars. The soil bins, soil bin cars, dynamometers and soil preparation cars were designed in Auburn. History proved the design to be essentially flawless.

J.M. Raymond Construction Company, Jacksonville, Florida, completed construction of the Laboratory in early 1936. Randolph was appointed its head and the Cotton Production Machinery Project was absorbed by the new laboratory.

International Significance

The National Soil Dynamics Laboratory (originally the Farm Tillage Machinery Laboratory and then the National Tillage Machinery Laboratory) was the world's first full-size laboratory equipped with separate bins containing various types of soil for controlled studies of the relationships between tillage tools, traction equipment and soils. Initially, work at the Laboratory centered around the study of machine parameters intended to improve machine design, but as the staff was increased its role gradually expanded to include the relation of machinery to soil compaction, soil and water conservation, and plant growth.

The laboratory has inspired the design of other tillage and traction research facilities but none of those facilities have developed to the size and capability of the NSDL program. The acceptance of visiting scholars

John W. Randolph (1896 - 1960)

Soil bin research equipment for studying the behavior of full-scale tillage tools.

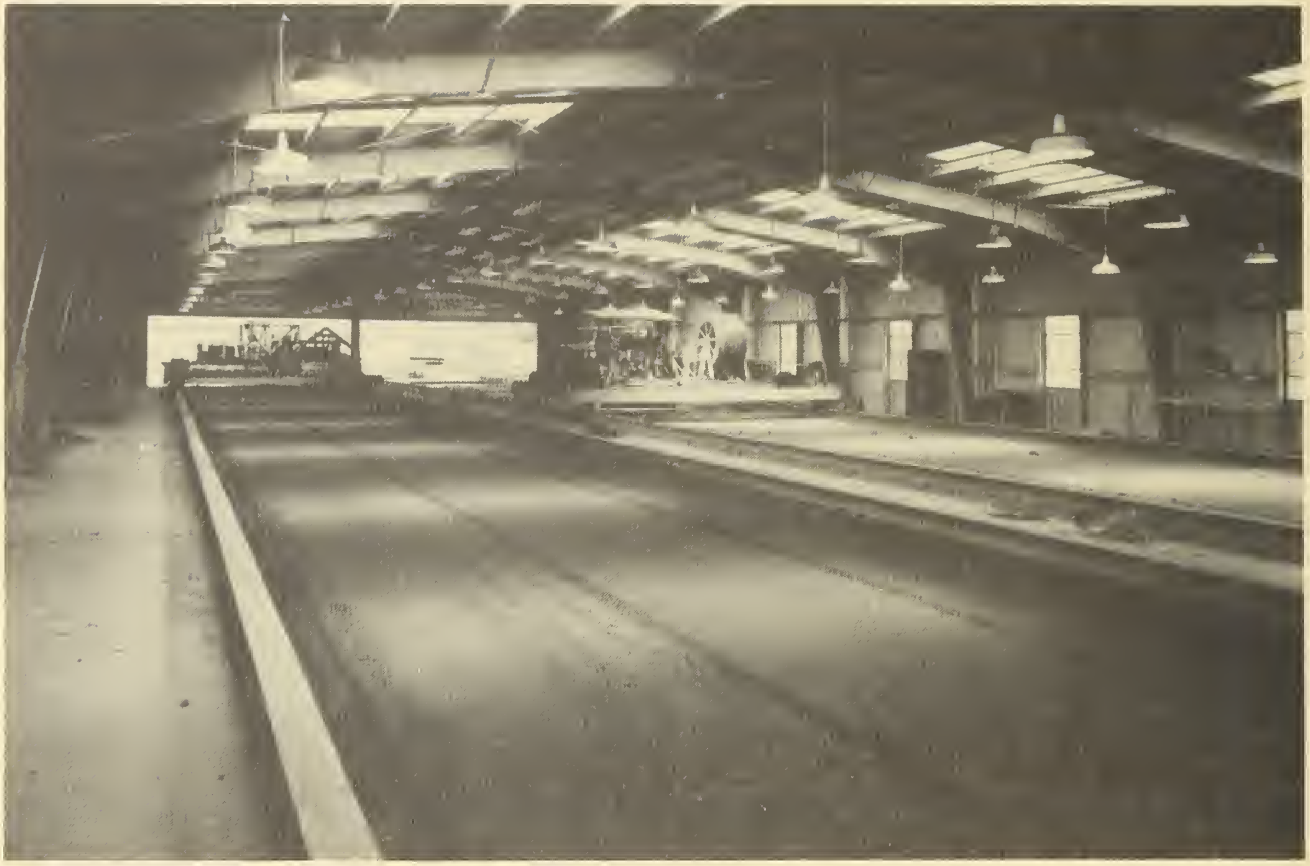
from around the world at the NSDL has provided a means for sharing specialized research facilities, knowledge and research experience to support research on mutual interests with other institutes. Cooperative agreements with the graduate schools of universities has provided an opportunity for graduate training and thesis research, and, thus, increased the number of well-trained scientists and engineers who have contributed to the national economies of the countries in which they now live and work.

NSDL has provided international leadership in the research, teaching and application of soil dynamics to problems concerning all forms of soil-engaging machinery. The basic nature of the research program has produced information that has applied to all uses of land including agriculture, mining, construction, military, and forestry.

For a period of fifty-five years the NSDL has been the only public research laboratory in the United States engaged in cooperative research on soil-machine problems. Research contacts have not been restricted to agricultural problems. NSDL has cooperated, consulted, or advised on far ranging topics outside agriculture such as the lunar rover vehicle, the landing gear for the C5A airplane, the burying of submarine communication cables, the burying of oil and gas pipelines, the mobility of military vehicles, the design of shelters for the MX missile, and the design of excavating machines.

General Description

The main feature of the original laboratory was seven outdoor soil bins 76.2 m (250-feet) long, 6.1 m (20-feet) wide and 0.61 m (2-feet) deep and two soil bins divided into four sections each 38.1 m (125-feet) long. Each bin was filled with a different type of soil. Soils, having mechanical compositions varying from sand to clay, were selected to provide the broadest possible characteristics that affected the physical properties and tillable behavior of soils found in the Southeastern United States. Test and soil preparation equipment operated on H-beam rails, mounted on the dividing walls between the bins. The only part of the test equipment to touch the soil was the tool that was being studied. The tread width for the power car, soil fitting cars, and cover cars was 6.5m (21 feet-2 inches) in order to straddle the soil bins. A building adjacent to the soil bins contained offices, soils laboratory, photographic dark room, drafting room, machine shop and storage space for the heavy equipment. The test equipment consisted of a power car to furnish the motive power and a dynamometer car to hold the tool being studied in its working position. Soil preparation cars included a utility car with a grader blade, watering hose, packing rollers and other soil preparation components. Mobile cover cars protected the soil bins from weather during test periods. A transfer car was used to move test and soil preparation cars to and from the work site.



Two covered soil bins 57.3 m (190-feet) long, 6.1 m (20-feet) wide, and 1.8 m (six-feet) deep provide environmental control for conducting complex soil-machine research measurements year around.

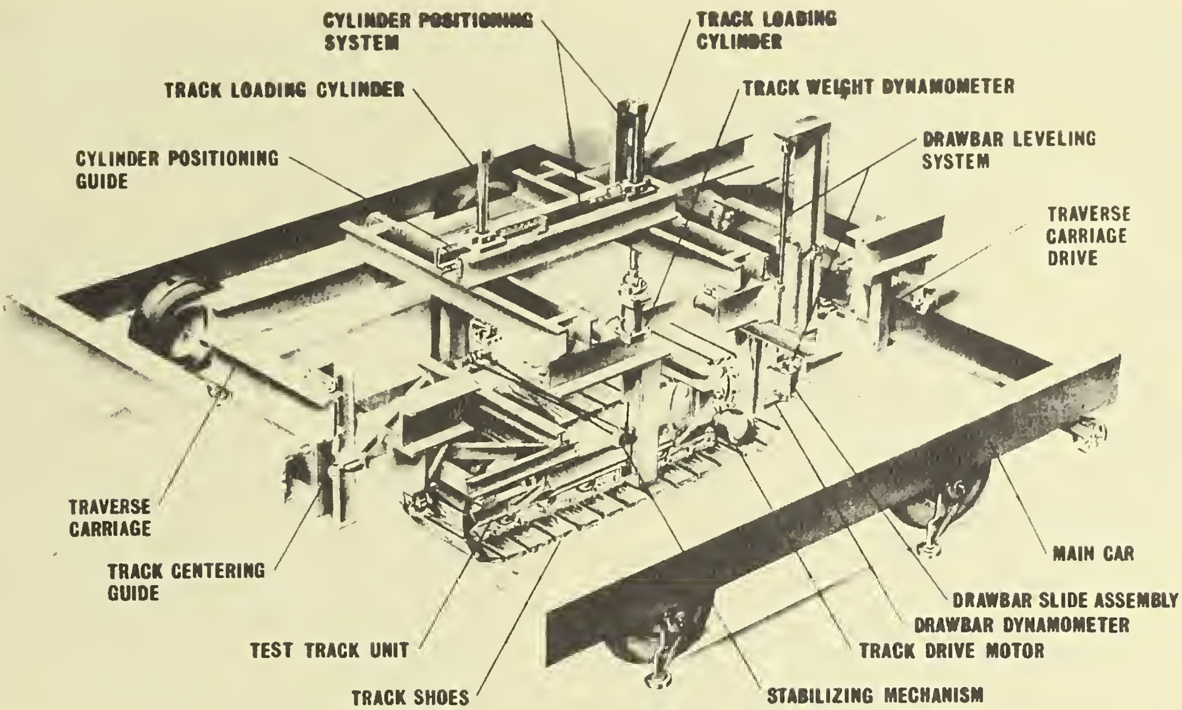
An office-laboratory building and two covered soil bins were constructed in 1962 by Bell Construction Company Montgomery, Alabama, and an equipment-storage building, constructed in 1970 by Bullard & Rogers, Inc., Montgomery, Alabama. The expansion was followed by the development of new generations of equipment which enhanced the laboratory's research capabilities. The NSDL remains a center of excellence with: a thriving soil dynamics research program; improved soil bins, mobile test and instrumentation equipment, data acquisition and analysis systems, machine shop; an internationally recognized research staff; reproduction and photographic equipment; and a comprehensive technical library.

Technical Background

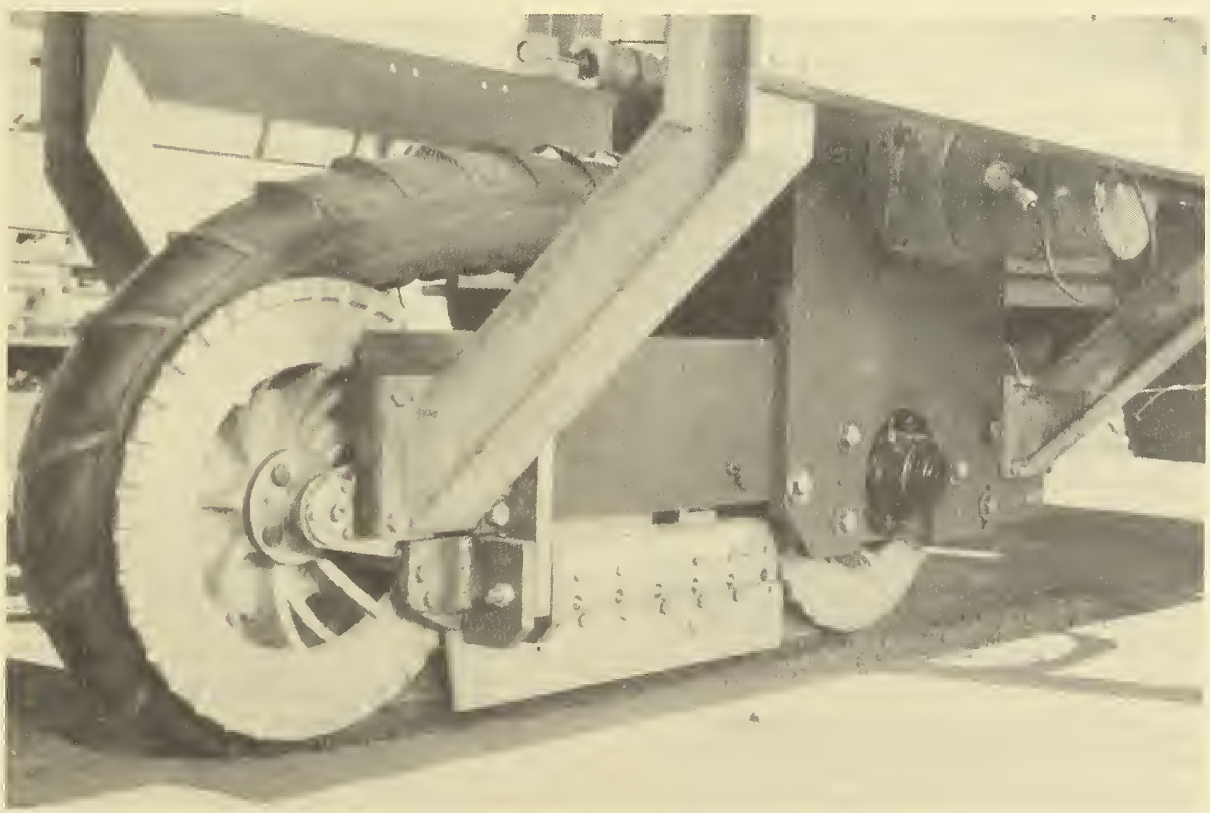
The original power car, powered with a 100 kW (135 horsepower) engine was supported on eight pneumatic tires and weighed nine tons. The car had a speed range variation from 0.06 to 3.05 m/s (0.2 to 10 miles per hour) and could attain a speed of 1.83 m/s (six miles per hour) in three seconds with a drawbar load of 22.3 kN (5,000 lb). A dynamometer was mounted in a separate car which was towed by the power car, and it could be moved vertically and laterally to position the hitch point of the tool at the desired height and the tool in the desired position in the soil bin during the conduct of measurements. The test procedure was to measure three, mutually-perpendicular forces and moments on the studied tool while a single parameter such as speed, angle of mounting, depth of soil cut or width of soil cut was varied. The nature of the forces and effect of the tool on the soil characterized the performance of the tool. The measured performance provided a means of evaluating those relevant parameters which could serve as design criteria.

Later generations of laboratory equipment included modernized versions of the power car, dynamometer car, and soil preparation cars. Tire and track testing cars, fitted with state-of-the-art electronic measuring, computing and analysis systems, were also developed for the study of soil-vehicle traction relations.

The traction research cars, which were self propelled, had an auxiliary means of powering the track or tire under study. Traction or transport performance was determined while the forward speed of the traction car, horizontal and vertical loads on the device, the



A research machine used in cooperative research with AT&T, Bell Telephone Laboratories to identify track parameters important in undersea traction and mobility.



Measuring of performance of a pneumatic track in uniform soil conditions and under controlled loading.

slip between the device and the soil, the inflation pressure of a tire, the torque required to turn the wheel or track, the sinkage of the device into the soil, and the drawbar pull of the device were measured and/or controlled. Simultaneously, the three-dimensional deformation of a tire and the stress distribution in the soil under and around the traction device could be measured with specialized transducers while the tire moved through the soil. A computer based data acquisition and control system provided computer control of experimental variables while simultaneously providing display of data secured during the conduct of the measurements which allowed rapid evaluation of experimental results.

Contributions

The National Soil Dynamics Laboratory has an extensive list of research accomplishments in virtually every aspect of machine-soil interactions, and has remained the central research facility in this field for over fifty years. Most modern agricultural soil-engaging equipment in service throughout the world have features or certain aspects which may be traced to the Laboratory's research program. Examples of the Laboratory's influence on the design and use of machines include:

— the effect of various geometrical shapes and types of materials on performance and life of soil engaging equipment.

— the effect of agricultural machinery traffic on soil compaction patterns and plant root growth.

— the development of strategies for the design and use of soil engaging elements to achieve enhanced tillage and traction performance.

— the development of controlled-traffic, slit-planting and under-the-row subsoiling as viable means, of reducing the influence of soil compaction in crop production systems.

— the establishment of parameters important to the performance of tillage tools, tracks and tires.

— the development of electronic based guidance systems for the control of agricultural machines in field operations.

— the development of basic mechanics, models and simulations for various important soil-machine relations.

— the development of soil dynamics as a scientific discipline.

— the development of electronic data processing systems to support a multi-faceted soil-bin based research facility.

ASAE Standards

Research work performed at the NSDL significantly contributed to twelve American Society of Agricultural Engineers Standards for the farm machinery industry:

ASAE S225.1, Chisel Plow, Field and Row Crop Cultivator Shanks and Ground Tool Mounting.

ASAE S230.4, Agricultural Machinery Management Data.

ASAE S296.3, Uniform Terminology for Traction of Agricultural Tractors, Self—Propelled Implement, and Other Traction and Transport Devices.

ASAE S290.1, Determining Cutting Width and Designated Mass of Disk Harrows.

ASAE S313.1, Soil Cone Penetrometer.

ASAE S385.3, Combine Harvester Tire Loading and Inflation Pressures.

ASAE S404T, Metric Row Spacings.

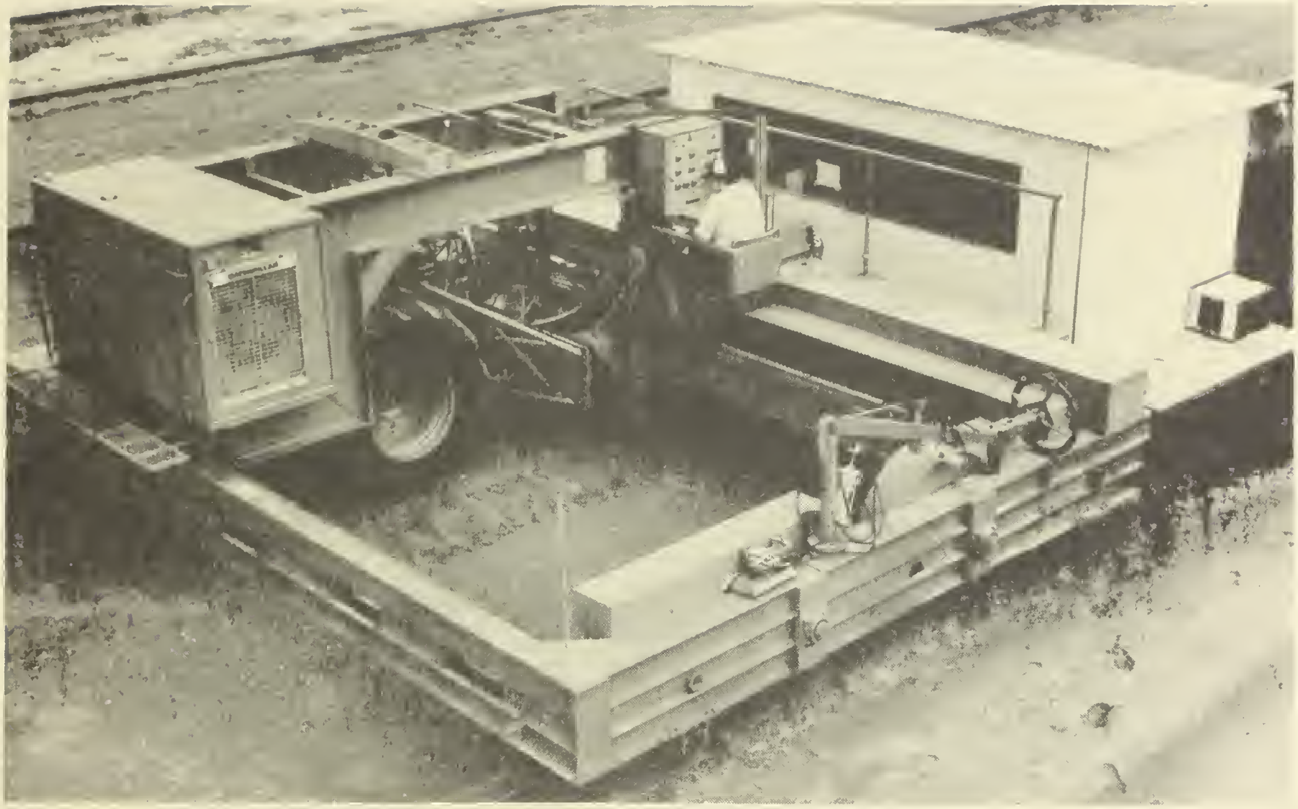
ASAE S414, Terminology and Definitions for Agricultural Tillage Implements.

ASAE S477, Terminology for Soil—Engaging Components for Conservation—Tillage Planters, Drills and Seeders.

ASAE EP236.1, Planning and Reporting Tillage Experiments.

ASAE EP291.2, Terminology and Definitions for Soil Tillage and Soil—Tool Relationships.

ASAE S430, Agricultural Equipment Tire Loading and Inflation Pressures.



The NSDL single wheel research machine used to study the soil and tire parameters influencing traction and mobility.

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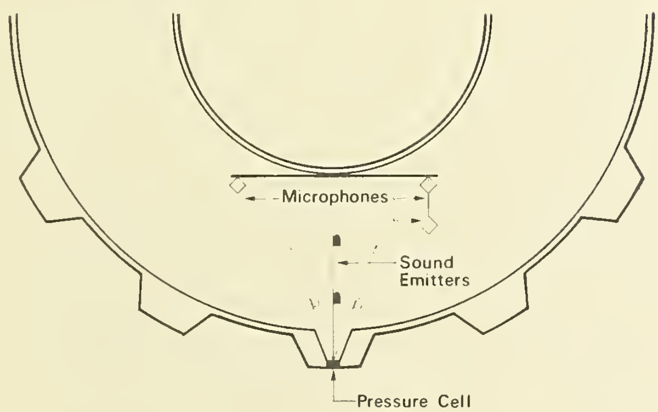


Tangential and normal stresses and deformations of pneumatic tires are measured with stress cells and a sonic digitizing unit.

The NSDL power-take-off driven rotary chisel mounted on an instrumented-tractor to study tillage effectiveness and energy efficiency.

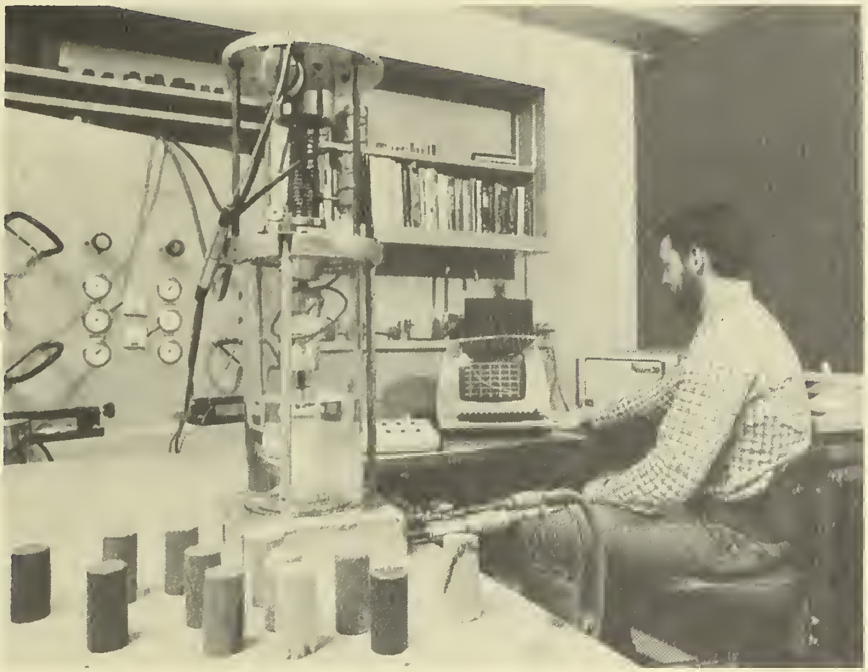
The History and Heritage Program of ASME

The ASME History and Heritage Recognition Program began in September 1971. To implement and achieve its goals, ASME formed a History and Heritage Committee, initially composed of mechanical engineers, historians of technology, and the curator of mechanical engineering at the Smithsonian Institution. The committee provides a public service by examining, noting, recording, and acknowledging mechanical engineering achievements of particular significance. The History and Heritage Committee is part of the ASME Council on Public Affairs and Board on Public Information.

The National Soil Dynamics Laboratory is the thirty-first International Historic Mechanical Engineering Landmark to be designated by the ASME. Since the Program began, 140 Historical Landmarks, five Mechanical Engineering Heritage Sites, and two Mechanical Engineering Heritage Collections have been recognized. Each recognized site or collection reflects its influence on society, either in its immediate locale, nationwide, or globally.

An ASME landmark represents a progressive step in the evolution of mechanical engineering. Site designations note events or developments of clear historical importance to mechanical engineers. Collections mark the contributions of a number of objects with special significance to the historical development of mechanical engineering.

The ASME Historic Mechanical Engineering Recognition Program illuminates our technological heritage and serves to encourage the preservation of the physical remains of historically significant works. The ASME program provides an annotated roster for engineers, students, educators, historians and travelers, and helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery. For more information, please contact the



Research apparatus to develop soil compaction models.

Public Information Department, American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017,(212)705-7740.

The ASAE Historic Commemoration Program

The ASAE Historical Commemoration program is managed by The ASAE Historical Commemoration Committee (M-123). The purpose of the program is to inform agricultural engineers of their great heritage, and thereby increase their pride and loyalty to their profession. The first ASAE landmark was designated in 1926. The National Soil Dynamics Laboratory is the twenty-fifth Landmark designated by ASAE.

The ASAE Historical Landmark Committee consists up of ASAE members from each of the Society's divisions or institutes. The committee provides a service to agriculture by designating notable items of historic importance as Agricultural Engineering Landmarks. Historic designations have been made of: sites where historic events occurred; inventions and developments of agricultural equipment; and, engineering and research contributions to design and design criteria. Agricultural Engineering Landmarks are prominently identified by bronze plaques which identify and explain the nature and significance of the achievement. Landmarks are only established for historic items that are unique to North America and only after a minimum period of 20 years following demonstration of their significance.

The ASAE Historic Landmark Committee also: (1) Encourages the preservation of objects, correspondence, documents, photos, and other records which form the basis of recorded history; (2) Increases the public awareness of how agricultural engineering has helped make possible the high living standards of the North American people; (3) Encourage the public to visit the honored sites; (4) Cooperates with other organizations which have parallel interests and objectives; and (5) Assists ASAE elements in the preparation and publication of their histories. For more information please contact the American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, Michigan 49085-9695 USA, (616) 429-0300.

ACKNOWLEDGEMENTS

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